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Bifulco

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(54) **NON-METALLIC ENGINE CASE INLET COMPRESSION SEAL FOR A GAS TURBINE ENGINE**

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(51) **Int. Cl.**

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| ***F16J 15/10*** | (2006.01) |
| *F16J 15/06* | (2006.01) |
| *F16J 15/46* | (2006.01) |

(52) **U.S. Cl.**

CPC ........... ***F16J 15/027*** (2013.01); ***F16J 15/104*** (2013.01); *F05D 2240/55* (2013.01); *F16J 15/025* (2013.01); *F16J 15/062* (2013.01); *F16J 15/46* (2013.01)

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CPC ........ F16J 15/022; F16J 15/025; F16J 15/027; F16J 15/10; F16J 15/102; F16J 15/104; F16J 15/46; F01D 11/005; F02C 7/28; B64D 33/02; F05D 2240/55

See application file for complete search history.

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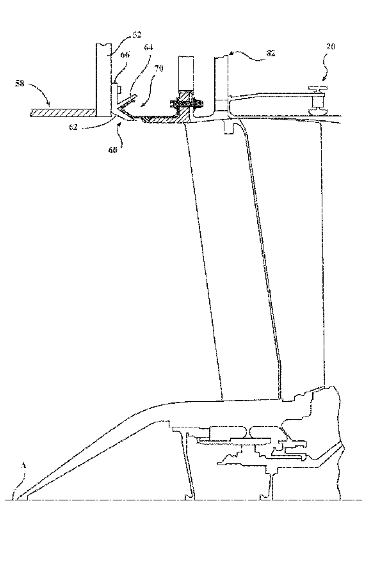
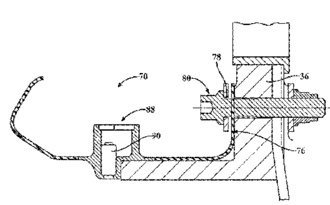
(57) **ABSTRACT**

A non-metallic engine case inlet compression seal for a gas turbine engine includes a non-metallic longitudinal leg section that extends from the non-metallic arcuate interface section and a non-metallic mount flange section that extends from the longitudinal leg section.

**4 Claims, 6 Drawing Sheets**





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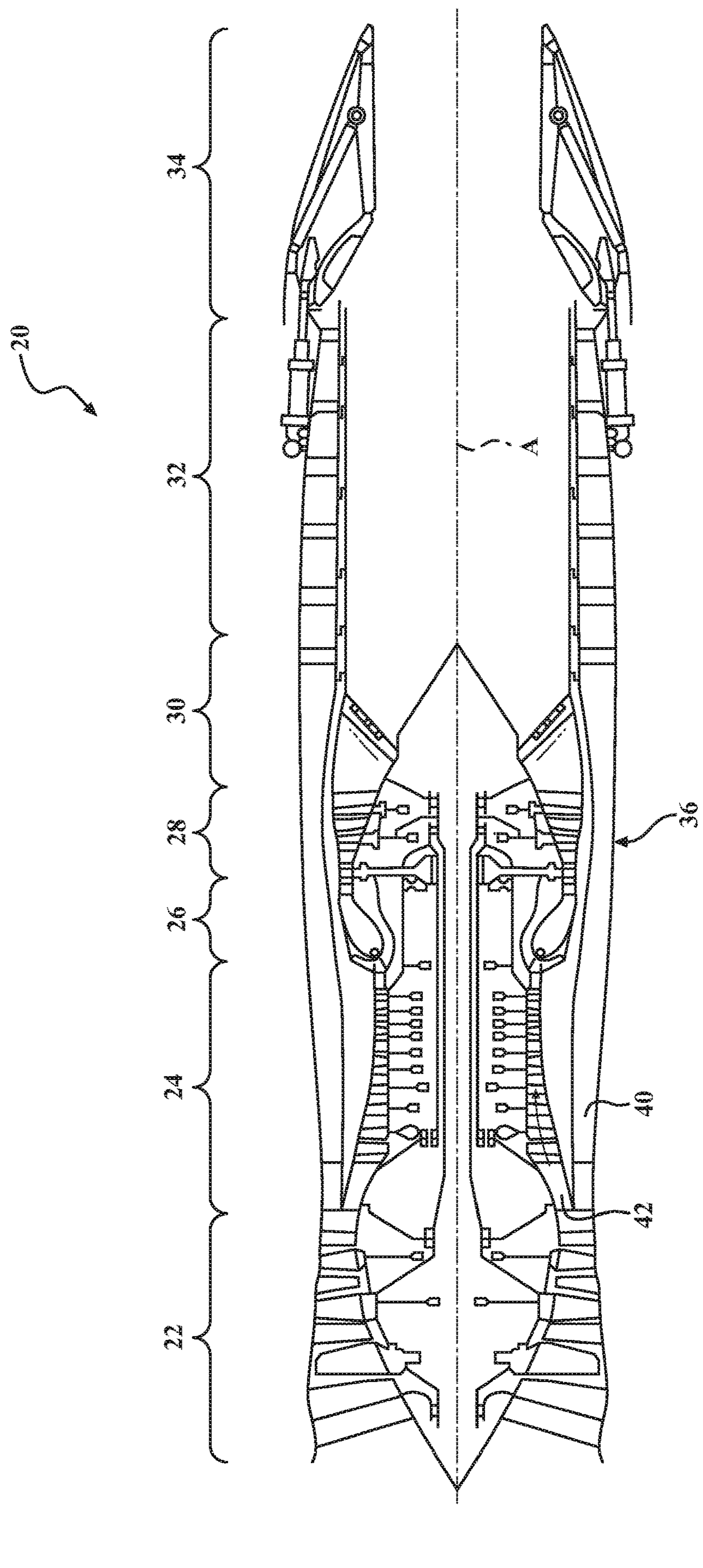



FIG. 1

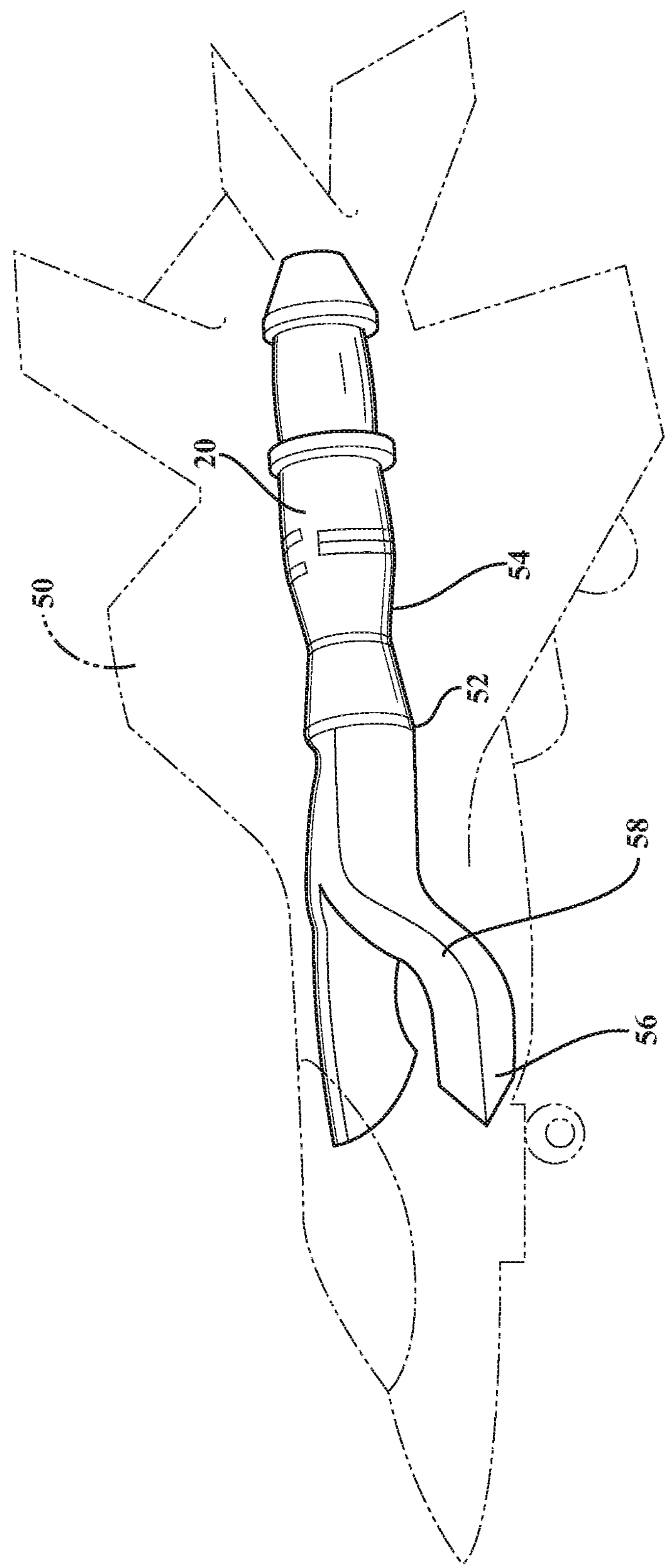



FIG. 2

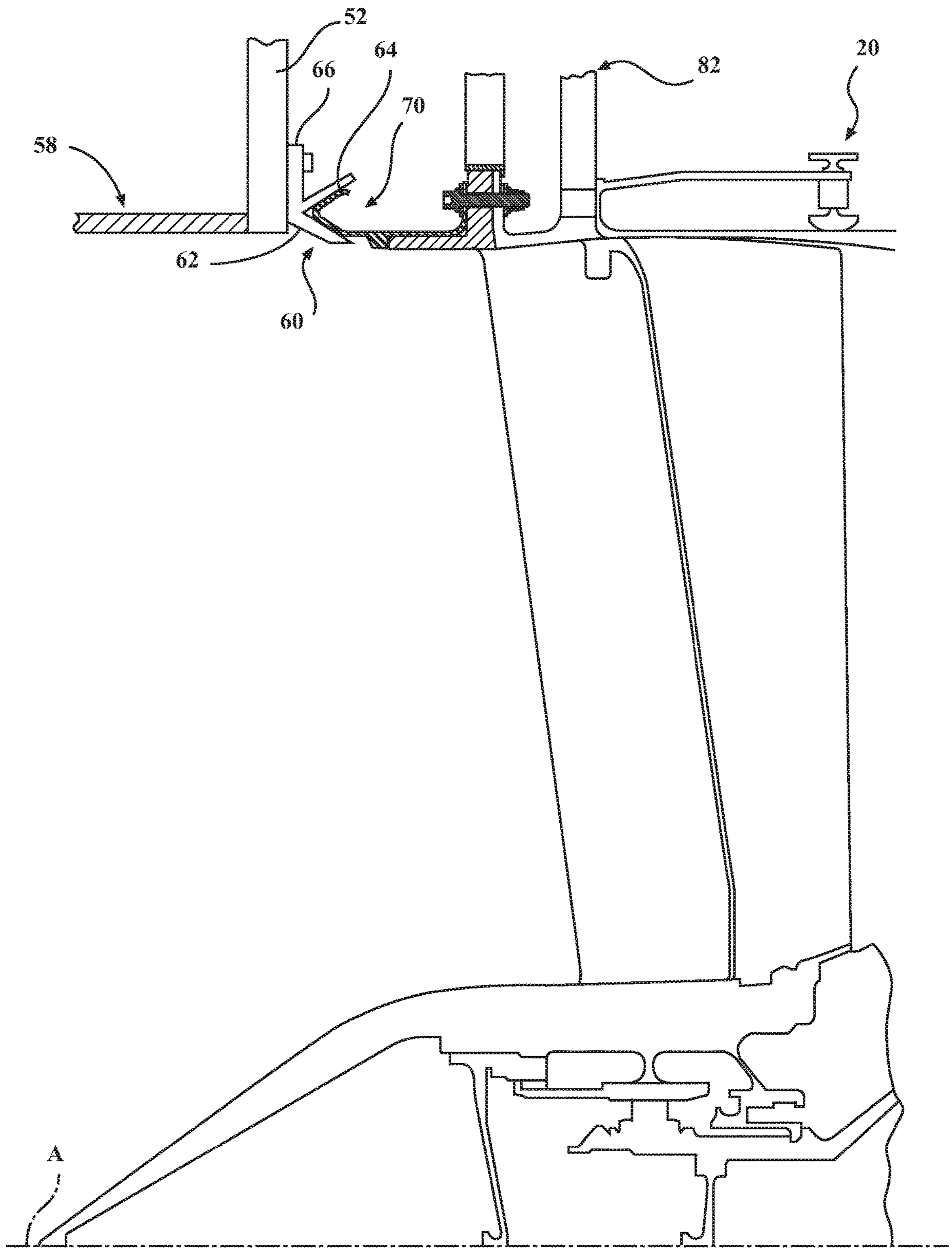



FIG. 3

FIG. 4

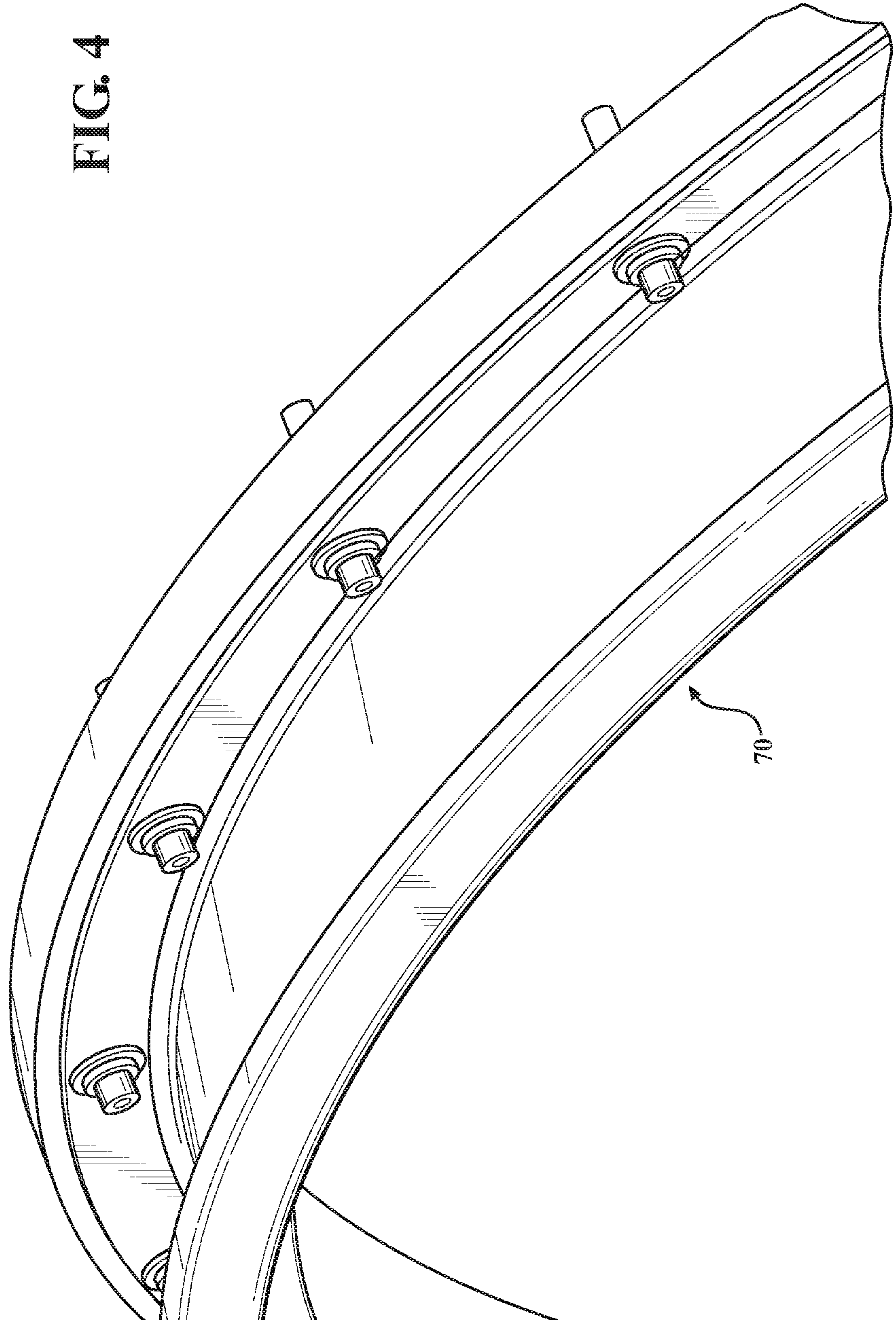


FIG. 5

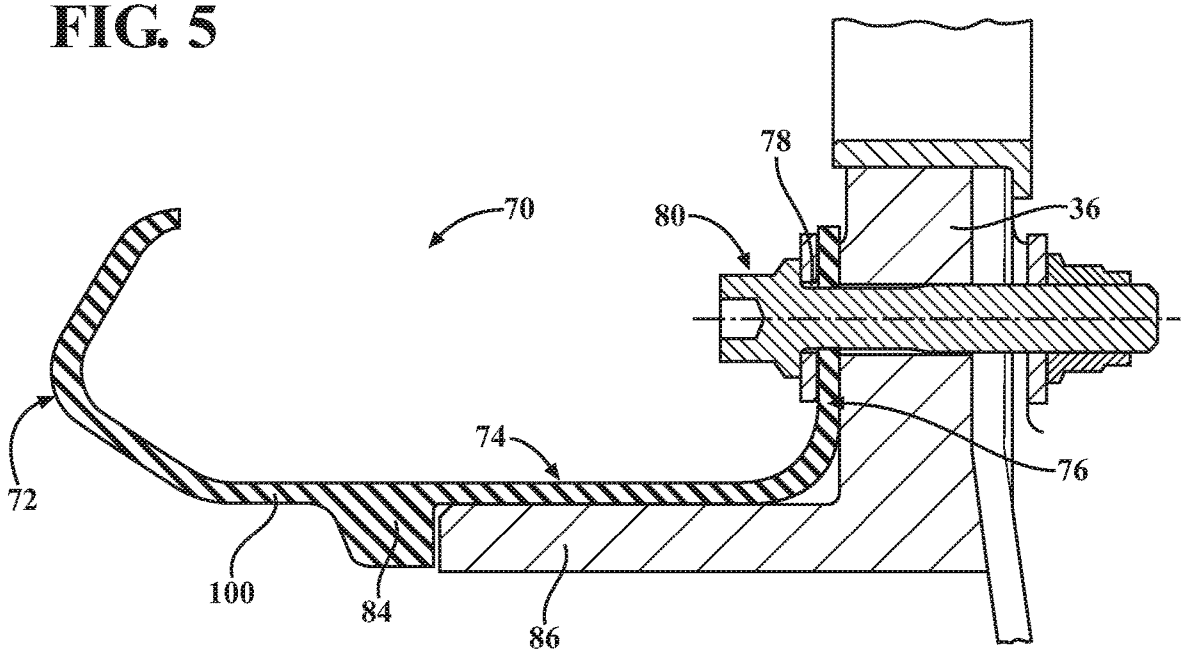



FIG. 6

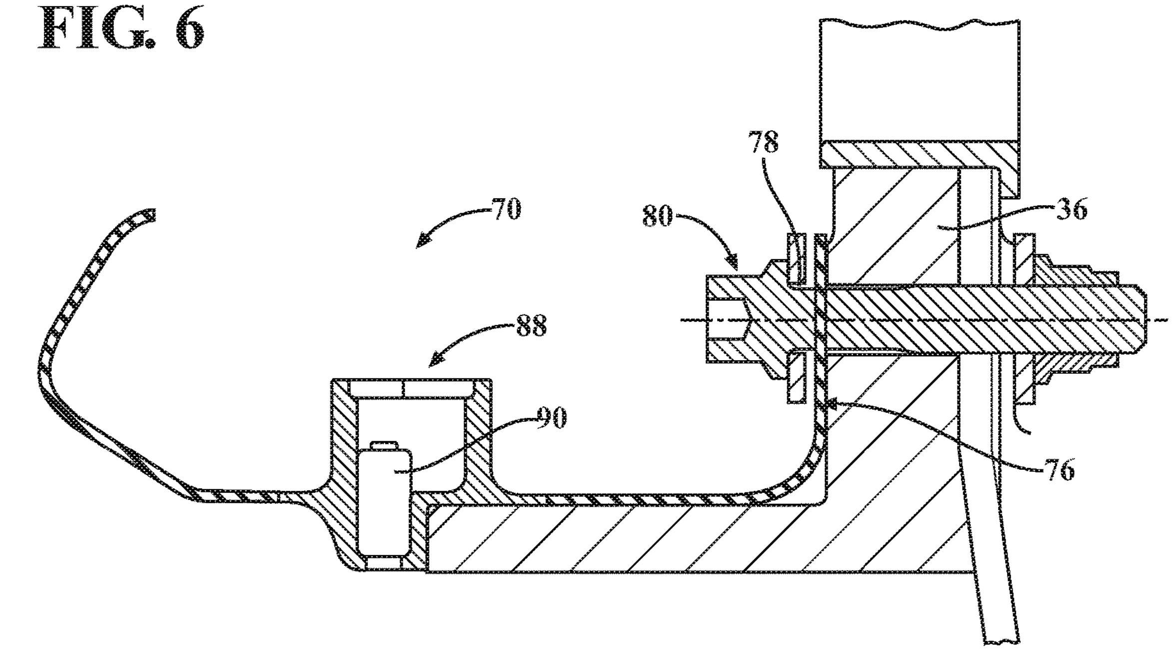


FIG. 7

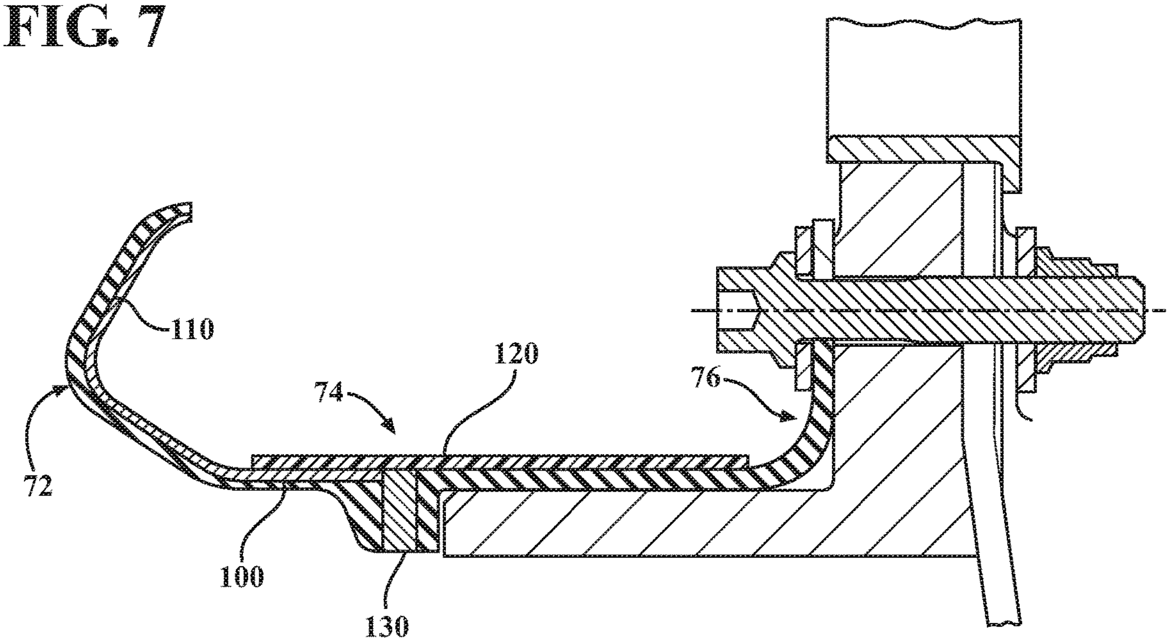
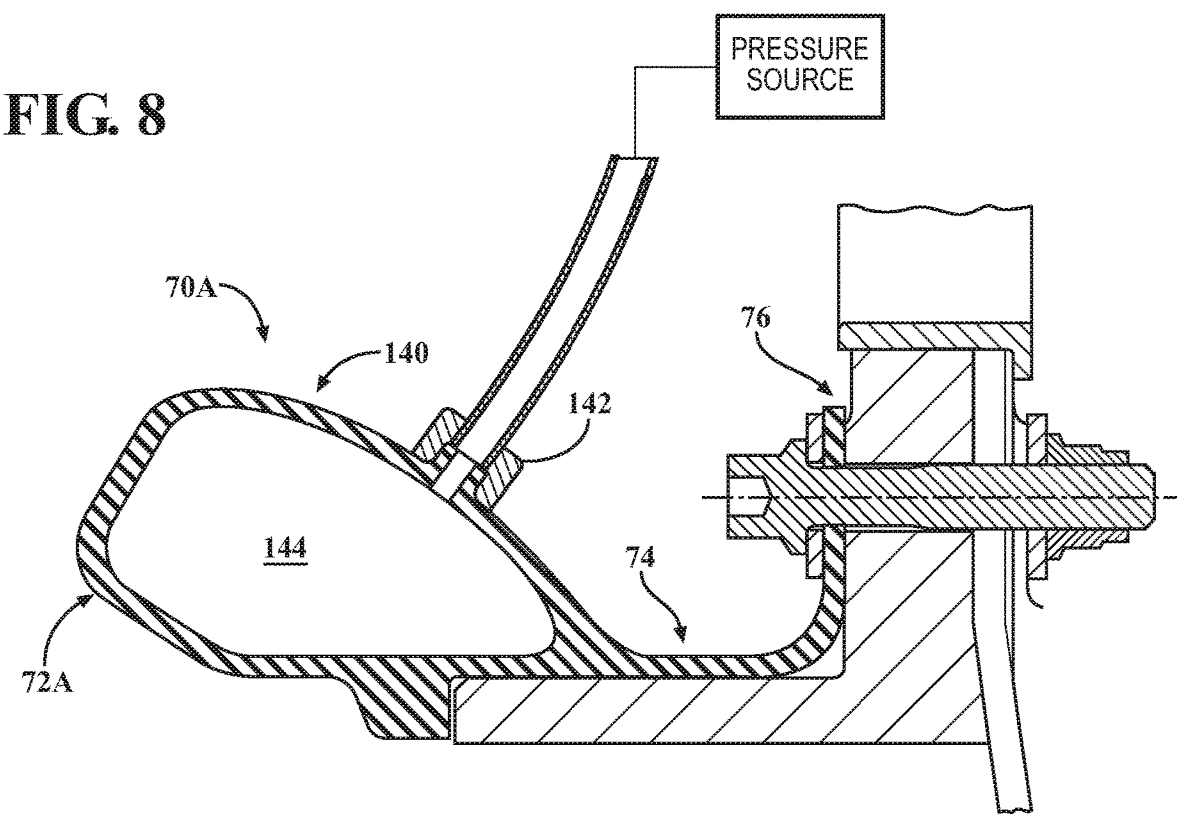

110
120
74
76
72
100
130

FIG. 8


PRESSURE SOURCE
70A
140
142
76
144
74
72A

# NON-METALLIC ENGINE CASE INLET COMPRESSION SEAL FOR A GAS TURBINE ENGINE

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S. patent application Ser. No. 16/108,758, filed Aug. 22, 2018, which is a divisional of U.S. patent application Ser. No. 14/948,657, filed Nov. 23, 2015, now U.S. Pat. No. 10,077,669, Issued Sep. 18, 2018, which claims the benefit of provisional application Ser. No. 62/084,603, filed Nov. 26, 2014.

## BACKGROUND

The present disclosure relates to a gas turbine engine and, more particularly, to a non-metallic engine case inlet compression seal therefor.

Gas turbine engines, such as those which power modern military aircraft, include a compressor section to pressurize a supply of air, a combustor section to burn a hydrocarbon fuel in the presence of the pressurized air, and a turbine section to extract energy from the resultant combustion gases and generate thrust. Downstream of the turbine section, an augmentor section, or "afterburner", is operable to selectively increase thrust. The increase in thrust is produced when fuel is injected into the core gases downstream of the turbine section and burned with the oxygen contained therein to generate a second combustion that is then passed through a variable area nozzle system.

In gas turbine powered aircraft, especially military aircraft, location of the gas turbine engine within the airframe reduces drag and signature. The internal engine location, however, necessarily requires airflow to be routed through an intake duct in the airframe to the engine. The intake duct is typically integrated with the airframe and interfaces with the engine case inlet via a compression seal interface to effectively communicate airflow to the engine. The compression seal interface often includes a K-seal mounted to the airframe and a J-seal mounted to the engine. Typically, the K-seal is non-metallic and the J-seal are manufactured of a titanium material. Although effective, the J-seal may be relatively difficult to manufacture and may be susceptible to cycle fatigue.

## SUMMARY

A non-metallic engine case inlet compression seal for a gas turbine engine, according to one disclosed non-limiting embodiment of the present disclosure includes a non-metallic arcuate interface section; a non-metallic longitudinal leg section that extends from the non-metallic arcuate interface section; and a non-metallic mount flange section that extends from the longitudinal leg section.

A further embodiment of the present disclosure includes, wherein the non-metallic arcuate interface section has a durometer different than that of the non-metallic longitudinal leg section.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein the non-metallic arcuate interface section has a durometer different than that of the non-metallic mount flange section.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein the non-metallic longitudinal leg section has a durometer different than that of the of the non-metallic mount flange section.



A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein each of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section have a different durometer.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein each of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section are integral.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein each of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section are integral.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein each of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section are manufactured of a silicone rubber.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section form a circular "J" seal.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein the non-metallic mount flange has a multiple of apertures.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein at least one of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section includes fiber reinforcement.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein the fiber reinforcement includes an aramid material.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, a fiber reinforcement that impregnates at least one of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, a fiber reinforcement bonded to an outer surface of at least one of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein the non-metallic arcuate interface section forms a bulb.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, an interface to the bulb to receive air to pressurize the bulb.

A non-metallic engine case inlet compression seal for a gas turbine engine, according to another disclosed non-limiting embodiment of the present disclosure includes an non-metallic arcuate interface section, the non-metallic arcuate interface section forms a bulb; and an interface to the bulb to receive and air to pressurize the bulb.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, a non-metallic longitudinal leg section that extends from the non-metallic arcuate interface section.

A further embodiment of any of the foregoing embodiments of the present disclosure includes a non-metallic mount flange section that extends from the longitudinal leg section.

A further embodiment of any of the foregoing embodiments of the present disclosure includes, wherein each of the non-metallic arcuate interface section, the non-metallic longitudinal leg section, and the non-metallic mount flange section are manufactured of a silicone rubber.

The foregoing features and elements may be combined in various combinations without exclusivity, unless expressly indicated otherwise. These features and elements as well as the operation thereof will become more apparent in light of the following description and the accompanying drawings. It should be understood, however, the following description and drawings are intended to be exemplary in nature and non-limiting.

## BRIEF DESCRIPTION OF THE DRAWINGS

Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiment. The drawings that accompany the detailed description can be briefly described as follows:

FIG. **1** is a general schematic view of an example gas turbine engine with a nozzle section according to one disclosed non-limiting embodiment;

FIG. **2** is a phantom view of an airframe illustrating a non-metallic engine case inlet compression seal between an aircraft intake duct and an engine case inlet of the gas turbine engine;

FIG. **3** is an exposed sectional of the non-metallic engine case inlet compression seal mounted to an engine case;

FIG. **4** is a partial perspective view of the non-metallic engine case inlet compression seal according to one disclosed non-limiting embodiment;

FIG. **5** is a sectional view of the non-metallic engine case inlet compression seal according to one disclosed non-limiting embodiment;

FIG. **6** is a sectional view of the non-metallic engine case inlet compression seal according to one disclosed non-limiting embodiment;

FIG. **7** is a sectional view of the non-metallic engine case inlet compression seal according to one disclosed non-limiting embodiment; and

FIG. **8** is a sectional view of the non-metallic engine case inlet compression seal according to one disclosed non-limiting embodiment.

## DETAILED DESCRIPTION

FIG. **1** schematically illustrates a gas turbine engine **20**. The gas turbine engine **20** is disclosed herein as a two-spool, low-bypass, augmented turbofan that generally incorporates a fan section **22**, a compressor section **24**, a combustor section **26**, a turbine section **28**, an augmenter section **30**, a duct section **32**, and a non-metallic engine case inlet compression seal **34** along a central longitudinal engine axis A. Although depicted as an augmented low bypass turbofan in the disclosed non-limiting embodiment, it should be appreciated that the concepts described herein are applicable to other gas turbine engines including non-augmented engines, geared architecture engines, direct drive turbofans, turbojet, turboshaft, multi-stream variable cycle, and other engine architectures with a nozzle system.

An outer case structure **36** and an inner case structure **38** define a generally annular secondary airflow path **40** around a core airflow path **42**. Various structures and modules may define the outer case structure **36** and the inner case structure **38** which essentially define an exoskeleton to support rotational hardware therein. Air that enters the fan section **22** is divided between core airflow through the core airflow path **42**, and secondary airflow through the secondary airflow path **40**. The core airflow passes through the combustor section **26**, the turbine section **28**, then the augmentor section **30**, where fuel may be selectively injected and burned to generate additional thrust through the non-metallic engine case inlet compression seal **34**.

The secondary airflow may be utilized for a multiple of purposes to include, for example, cooling, pressurization and variable cycle operations. The secondary airflow as defined herein is any airflow different from the core airflow. The secondary airflow may ultimately be at least partially injected into the core airflow path **42** adjacent to the duct section **32** and the non-metallic engine case inlet compression seal **34**. It should be appreciated that additional airflow streams, such as third stream airflow typical of variable cycle engine architectures, may additionally be provided.

With reference to FIG. **2**, the engine **20** is removably located within an airframe **50** (illustrated schematically). It should be appreciated that various airframe **50** configurations will benefit herefrom. The airframe **50** generally includes an engine bulkhead **52**, an engine bay **54**, an inlet **56**, and an intake duct **58**. The intake duct **58** is integrated within, or forms a portion of, the airframe **50**. The bulkhead **52** is located generally between the intake duct **58** and the engine bay **54**.

With reference to FIG. **3**, the engine **20**, which is situated in the engine bay **54**, is coupled to the intake duct **58** by a compression interface formed by a bulkhead seal **60** and a non-metallic engine case inlet compression seal **70** (FIG. **4**). The bulkhead seal **60**, such as a K-seal, is mounted to the bulkhead **52**. The non-metallic engine case inlet compression seal **70**, such as J-seal, is mounted to the outer case structure **36**. Thus, the engine **20** is sealed with the intake duct **58** through the compression interface formed by the J-seal and the K-seal such that air is routed from the inlet **56** to the engine **20**. For clarity, only a circumferential portion of the non-metallic engine case inlet compression seal **70** and the bulkhead seal **60** are shown. Normally, the non-metallic engine case inlet compression seal **70** and the bulkhead seal **60** entail full 360° rings, of either a single piece or ring segments.

The bulkhead seal **60** generally includes an inner leg **62**, an outer leg **64**, and a mount flange **66**. The inner leg **62** and the outer leg **64** at least partially receive the non-metallic engine case inlet compression seal **70** therebetween. The mount flange **66** permits attachment of the bulkhead seal **60** to the engine bulkhead **52**. The bulkhead seal **60** is typically manufactured of an alloy such as titanium. It should be appreciated that various configurations may be provided.

With reference to FIG. **5**, the non-metallic engine case inlet compression seal **70** generally includes a non-metallic arcuate interface section **72**, a non-metallic longitudinal leg section **74**, and a non-metallic mount flange section **76**. The non-metallic arcuate interface section **72** extends from the non-metallic longitudinal leg section **74** to, in this example, form a generally "J" shape. The non-metallic mount flange section **76** extends transversely from the non-metallic longitudinal leg section **74** and includes a multiple of apertures **78**. Each of the apertures **78** receives a fastener **80** to mount the non-metallic engine case inlet compression seal **70** to the outer case structure **36** forward of the fan section **22**. In this embodiment, the non-metallic engine case inlet compression seal **70** extends from the outer case structure **36** from the forward circumferential edge of the fan section **22** forward of an engine mount **82** (FIG. **3**).

The non-metallic longitudinal leg section **74** may include a stepped surface **84** that abuts a forward edge **86** of the outer case structure **36**. Alternatively, the non-metallic longitudinal leg section **74** may form an aperture **88** (FIG. **6**) at least partially through the stepped surface **84** to receive a sensor **90** (illustrated schematically) such as a pressure sensor therein. The aperture **88**, in this example, is continuous with the stepped surface **84**.

The non-metallic engine case inlet compression seal **70** is manufactured of a non-metallic material **100** such as silicone rubber formed, or extruded, to shape. It should be appreciated that various non-metallic materials may be utilized. The cross section and stiffness of the non-metallic engine case inlet compression seal **70** is arranged to seal the interface irrespective of relative motion between the airframe **50** and the engine **20** such as is typical during maneuvering flight.

With reference to FIG. **7**, in another disclosed non-limiting embodiment, the material **100** may include fiber reinforcement **110** with, for example, meta-aramid material fibers. The fiber reinforcement **110** may be utilized to impregnate the non-metallic engine case inlet compression seal **70** to provide strength and stiffness, alternatively, or in addition thereto, fiber reinforcement **120** may, be bonded to the outer surfaces of the non-metallic engine case inlet compression seal **70** to provide strength and durability. In one example, the fiber reinforcement **110** may be located to directly contact upon the bulkhead seal **60** for strength, reduced friction, etc. In another example, the fiber reinforcement **110** may be located as reinforcement for strength or increased bond strength. It should be appreciated that beyond mechanical retention of fasteners the non-metallic engine case inlet compression seal **70** may also be retained via bonding. The material **100** may further include various coatings to, for example, increase lubricity, heat resistance, etc.

In another disclosed non-limiting embodiment, one or more of the non-metallic arcuate interface section **72**, the non-metallic longitudinal leg section **74**, and the non-metallic mount flange section **76**, may be manufactured of different non-metallic materials. In one example, the non-metallic mount flange section **76** may be manufactured of a material that has a relatively higher durometer than that of the non-metallic arcuate interface section **72**, yet be integrated thereto such as via co-molding, over-molding, or other such manufacturing process. In another disclosed non-limiting embodiment, the non-metallic longitudinal leg section **74** may be manufactured of a relatively rigid non-metallic material, or include an insert **130** thereof.

With reference to FIG. **8**, in another disclosed non-limiting embodiment, an non-metallic engine case inlet compression seal **70**A may include a non-metallic arcuate interface section **72**A that forms a bulb **140**. The bulb **140** may include an interface **142** to receive air from an air pressure source to pressurize a pressurization region **144** formed by the bulb **140**. The air pressure source, for example, may be secondary airflow sourced from the secondary airflow path **40** (FIG. **1**). The bulb **140** is thereby pressurized to facilitate formation of a conforming compression seal that readily provide an increased contact surface with the bulkhead seal **60**. That is, the pressurization region **144** thereby drives the bulb **140** into the bulkhead seal **60** to increase contact therewith.

The non-metallic engine case inlet compression seal is relatively uncomplicated to manufacture yet provides for relatively complex geometries that may include one or more pressurized regions. The non-metallic material also provides for considerable design options such as shape, durometer, coatings, reinforcement, and/or pressurization. The non-metallic engine case inlet compression seal readily tolerates application temperatures and provides flexibility of design for unique properties at various sections such as rigid and stiff at fastening location, flexible and resilient at a seal interface, and/or rigid where pressure sensors or other features may be installed. The non-metallic engine case inlet compression seal is also relatively insensitive to shipping and handling conditions. The non-metallic engine case inlet compression seal also avoids the necessity of metallic seal stop crack drilling may be readily mended.

The use of the terms "a," "an," "the," and similar references in the context of description (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or specifically contradicted by context. The modifier "about" used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., it includes the degree of error associated with measurement of the particular quantity). All ranges disclosed herein are inclusive of the endpoints, and the endpoints are independently combinable with each other. It should be appreciated that relative positional terms such as "forward," "aft," "upper," "lower," "above," "below," and the like are with reference to normal operational attitude and should not be considered otherwise limiting.

Although the different non-limiting embodiments have specific illustrated components, the embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from any of the non-limiting embodiments in combination with features or components from any of the other non-limiting embodiments.

It should be appreciated that like reference numerals identify corresponding or similar elements throughout the several drawings. It should also be appreciated that although a particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit herefrom.

Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present disclosure.

The foregoing description is exemplary rather than defined by the limitations within. Various non-limiting embodiments are disclosed herein, however, one of ordinary skill in the art would recognize that various modifications and variations in light of the above teachings will fall within the scope of the appended claims. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practiced other than as specifically described. For that reason the appended claims should be studied to determine true scope and content.

What is claimed is:

**1**. A gas turbine engine, comprising:

an outer case structure defined along an engine axis;

a non-metallic mount flange section having a multitude of apertures to mount said non-metallic mount flange section to said outer case structure forward of a fan section of said gas turbine engine;

a non-metallic longitudinal leg section that extends transversely from said non-metallic mount flange section, said non-metallic longitudinal leg section at least partially radially supported on said outer case structure; and a non-metallic arcuate interface section that extends from said non-metallic longitudinal leg section, said non-metallic arcuate interface section defined around said engine axis, wherein said non-metallic arcuate interface section has a durometer hardness different than a durometer hardness of said non-metallic longitudinal leg section.

**2**. The gas turbine engine as recited in claim **1**, wherein said non-metallic longitudinal leg section is generally parallel to said engine axis.

**3**. The gas turbine engine as recited in claim **1**, wherein said non-metallic longitudinal leg section comprises a stepped surface that abuts a forward edge of said outer case structure.

**4**. The gas turbine engine as recited in claim **1**, wherein said outer case structure that forms said forward edge of said outer case structure is stepped.

* * * * *